Multi-Physical Co-Design of Next-Generation Axial Motors for Aerospace Applications

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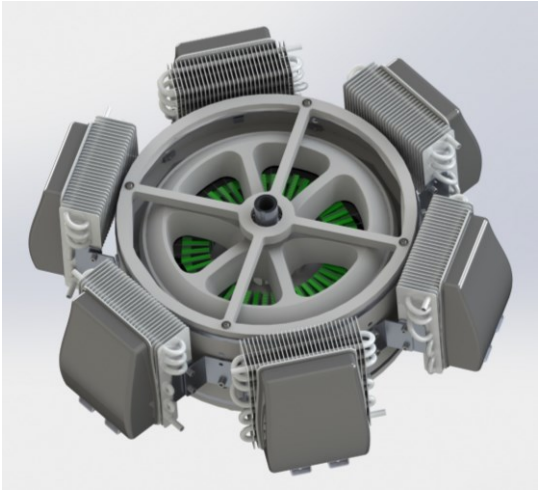
Project Vision

Significantly increase electric aircraft powertrain power density using

- Dual rotor axial flux motor
- SiC multilevel inverter
- Minichannel end winding heatsinks
- Zeolite thermal energy storage
- Nanocomposite insulation
- Carbon fiber reinforced structure



REEACH / ASCEND / CABLES Annual Program Review Meeting
June 28-30, 2022

Project Team Members

Fed. funding:	$4.8M
Length	42 mo.

Team member	Location	Role in project
Texas A&M	College Station, TX	Project lead
University of Texas at Dallas	Richardson, TX	Support modeling efforts

Electrical Eng.

Hamid Toliyat

Matthew Gardner

Prasad Enjeti

Mechanical Eng.

Bryan Rasmussen

Dion Antao

Jaime Grunlan

Jonathan Felts

Materials Science

Patrick Shamberger

Aerospace Eng.

Moble Benedict

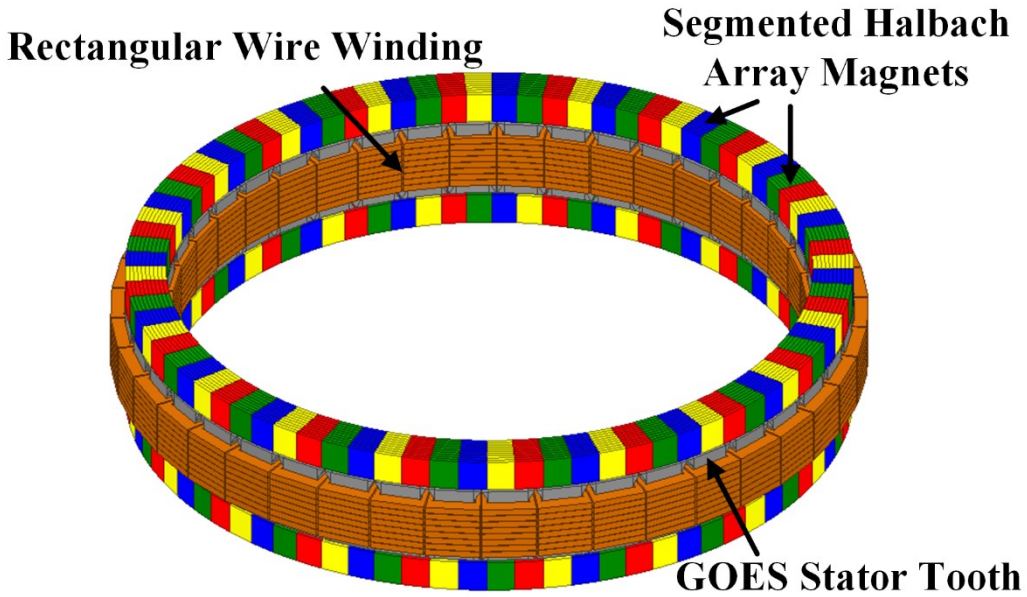
Motor

Motor Features

- Dual rotor, yokeless segmented stator
- Grain oriented electrical steel
- Segmented Halbach array of magnets
- Carbon fiber reinforced polymer structural components
- 6 phases

Motor Metrics

- Max speed: 5000 RPM (no gearbox)
- Peak power: 250 kW
- Mass: 7.5 kg (EM) + 4 kg (Structural)
- Efficiency: 94% (takeoff) - 95% (cruise)



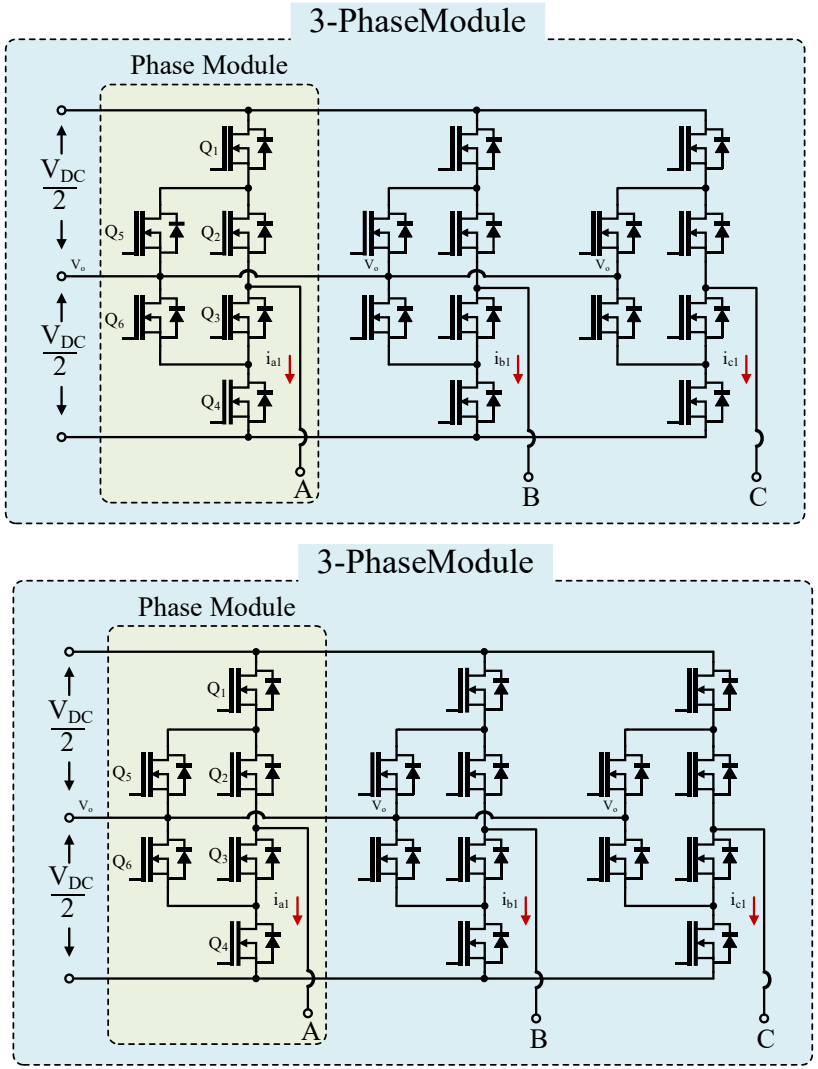
Inverter

Inverter Features

- SiC devices
- Multilevel topology
- 6-phases

Inverter Metrics

- Peak power: 266 kW
- Mass: < 2 kg (not counting TMS)
- Efficiency: 99%



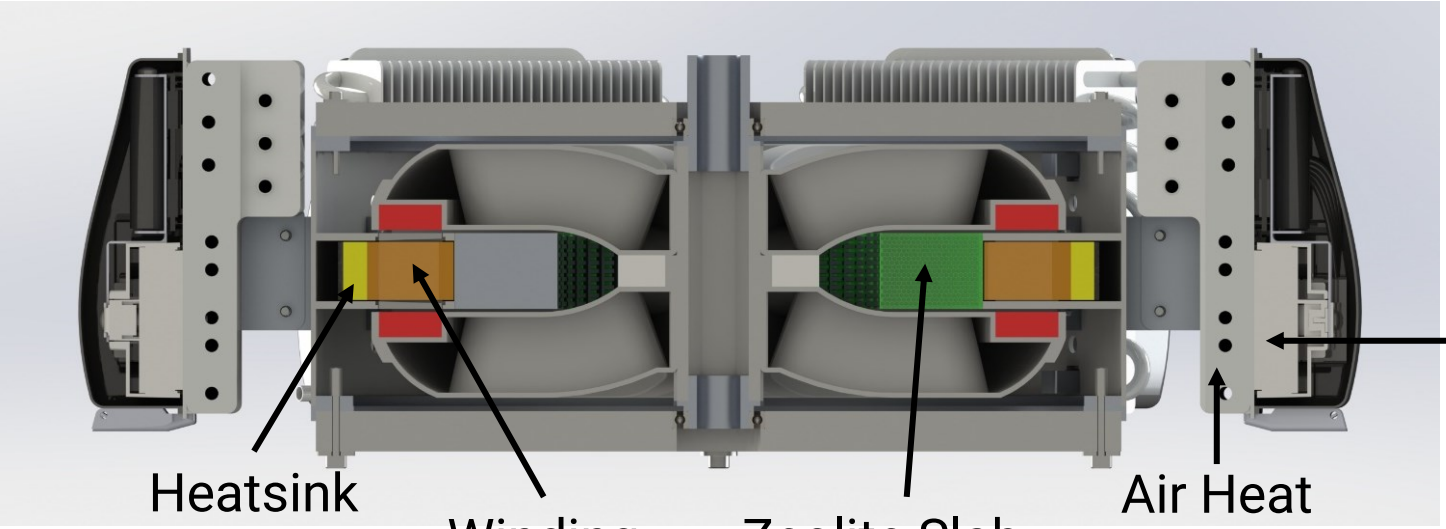
Thermal Management System (TMS)

TMS Features

- Pumped EG-water cooling system
- Minichannel heatsinks on end windings
- Shared air heat exchanger for motor and inverter
- Zeolite thermal energy storage
- Nanocomposite winding insulation

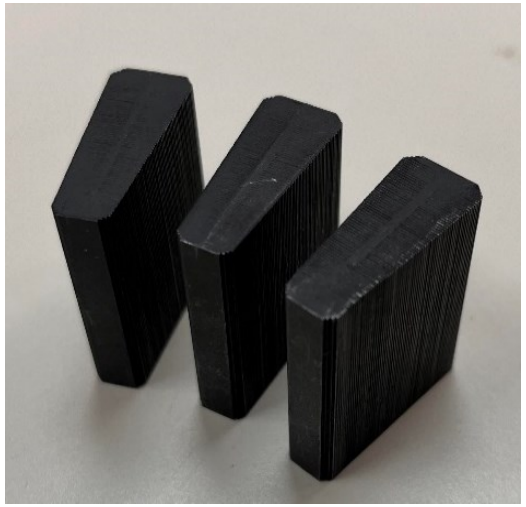
TMS Metrics

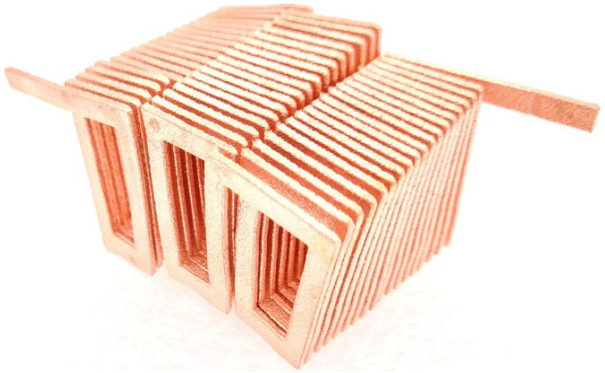
- Mass: <6 kg
- Power consumption: 40 W
- Takeoff COP: 495
- Cruise COP: 140

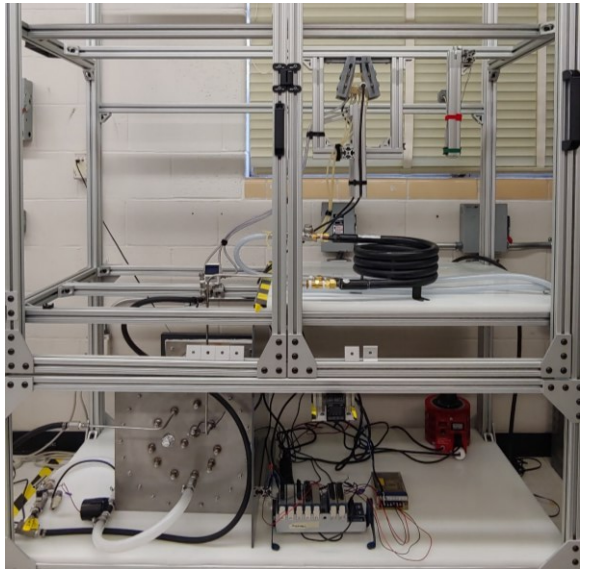


Phase I Testing

- Testing zeolite thermal energy storage and nanocomposite insulation at the component level
- Will test 3-tooth motorette with end winding heatsinks and zeolites

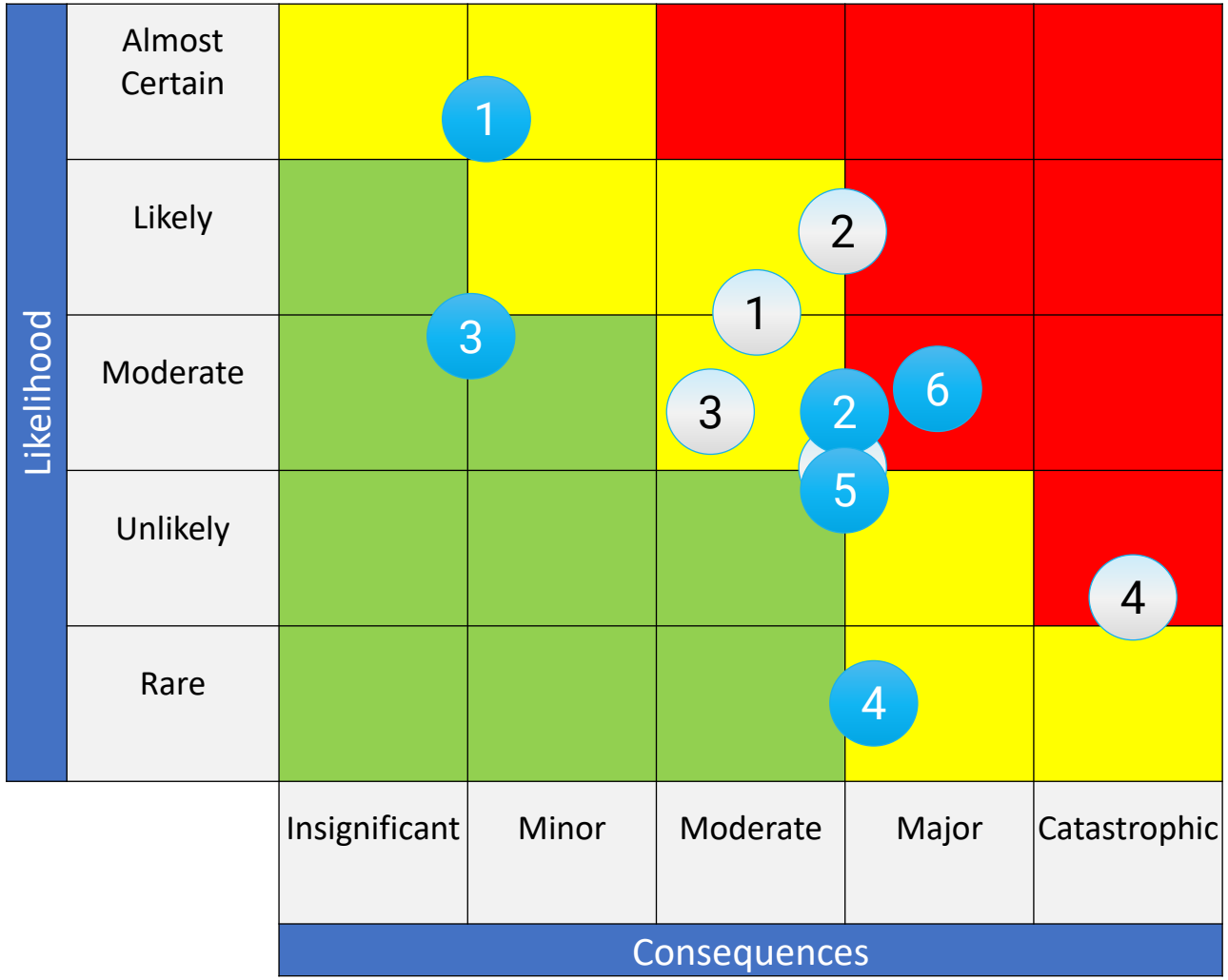






Risk Update

X Now X Start of project



Risk	#
Insulation does not achieve original targets	1
Zeolite provides inadequate energy storage at acceptable motor temperatures	2
Lower than initially expected copper fill factor in motor	3
TMS control instability	4
Inability to license technology	5
Surface of windings is too rough	6

Technology-to-Market Approach

- Commercialization will involve licensing or start-up companies
- Near-term markets: regional air mobility, urban air mobility
  - For battery electric, a small gain in efficiency is worth some weight
- Long-term market: longer range aircraft
- Publications: 1 journal paper, 3 conference papers, 2 patent applications filed

Needs and Potential Partnerships

- Licensees
- Regulatory and manufacturing expertise

Looking Ahead

Phase I

- Test motorette to verify that we can extract enough heat
- Validate and calibrate models

Phase II

- Prototype and test the subsystems and the full powertrain
- Manufacturing/supply chain analysis
- Regulatory analysis and planning
- Evaluate design changes for near term market customers

Q & A

https://arpa-e.energy.gov